Innovative Fiber-Optic Gyroscopes (FOGs) for High Accuracy Space Applications, Phase II

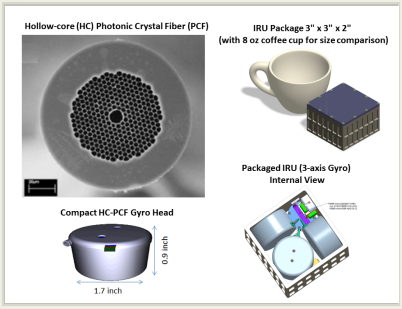
Completed Technology Project (2016 - 2021)

Project Introduction

This project aims to develop a compact, highly innovative Inertial Reference/Measurement Unit (IRU/IMU) that pushes the state-of-the-art in high accuracy performance from a FOG with drastically reduced optical and electronic package volumes. The proposed gyroscope is based on an innovative approach using Photonic Crystal Fiber (PCF) coils that reduces the major gyro error sources and enables a radiation hard sensor in smaller volume compared to state-of-the-art. Phase 1 addressed the feasibility of the PCF FOG concept, demonstration of critical components, performance/size tradeoffs, and preliminary designs of FOG-based IRU and IMU, leading to a prototype gyro to be designed and built in Phase 2. In particular, Phase 1 involved a comprehensive study of available state-of-the-art PCF and associated components. Based on this, three different PCFs were obtained and extensively tested for suitability in small gyro applications emphasizing tight bending diameters and temperature tests. The tests demonstrated that the technology is sufficiently developed to enable implementation of advanced PCF-based FOGs in the near future. Phase 2 will (1) implement selected PCF for the gyro application, develop and evaluate components including the PCF coil, modulator and polarizers, and develop the required support infrastructure and tooling, (2) perform performance modeling and trade-offs followed by a complete PCF gyro design, (3) evaluate low-power solutions for the light source and electronics and preliminary valuation of unique electronic miniaturization designs, (4) deliver a tested and validated gyro sensor and electronics, and (5) design a compact open-loop PCF FOG-based 3-axis IRU system. The Phase 2 strategy includes a development and integration plan, potential demonstration opportunities, program schedule, transition activities, and estimated costs. Our Phase 2 base work plan is designed to advance the TRL to 5, with TRL 6 being obtained in a Phase 2-X program.

Anticipated Benefits

The overall objective set for this SBIR project is developing and demonstrating a Photonic Crystal Fiber (PCF)-based FOG sensor with <2 cubic inch volume that can ultimately be packaged into a full Inertial Measurement Unit (IMU) with < 28 cubic inch volume delivering high-end TG performance, or an IMU with a volume < 80 cubic inches for NG and high accuracy performance, as well as evaluating a drastically miniaturized, high density electronics package with form factors ultimately consistent with radiation hard (RH) components packaged small volume as may be required for NASA's smaller satellites and/or long life spacecraft missions. NASA applications include space missions, from High Earth Orbits (HEO) to lunar and beyond Earth exploration, such as asteroids, wherever measurement and correction of attitude, position, velocity and acceleration and/or accurate pointing performance are needed for, e.g., spacecraft formation flying and autonomous rendezvous with asteroid, space-based laser applications, high accuracy pointing systems for space telescope platforms, and the new generation of small satellites.Applications range from



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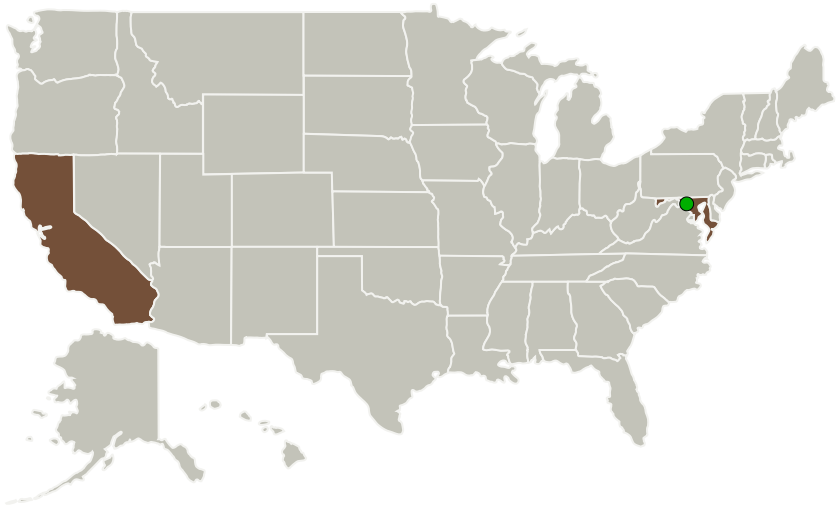
rate sensors and gyros used in commercial avionics to navigational inertial reference and measurement units needed for commercial small satellites and landing spacecraft, to gas and oil applications such as measurement-while-drilling (MWD) deployed in horizontal directional drilling. The proposed work will significantly benefit the commercial aviation industry as well as sensor arrays for medical applications and homeland security robotic disarming of bombs. Reducing the size, weight, power (and cost of these sensors and improving robustness against harsh environmental risk factors - all without loss of performance - is also critical for many advanced interceptor and satellite platforms that are of interest to DOD and advanced aerospace applications.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Intelligent Fiber Optic Systems Corporation	Lead Organization	Industry	Santa Clara, California
Goddard Space Flight Center(GSFC)	Supporting Organization	NASA Center	Greenbelt, Maryland

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Intelligent Fiber Optic Systems Corporation

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

Carlos Torrez

Project Managers:

Edward P Davis
Joseph Famiglietti

Principal Investigator:

Behzad Moslehi

Co-Investigator:

Behzad Moslehi

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Primary U.S. Work Locations	
California	Maryland

Project Transitions

May 2016: Project Start

November 2020: Closed out

Closeout Documentation:

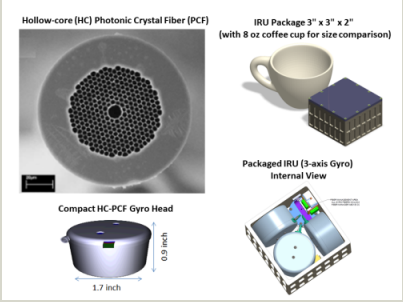
- Final Summary Chart*(https://techport.nasa.gov/file/139778)*

November 2021: Closed out

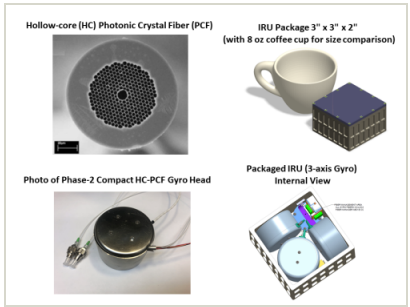
Closeout Documentation:

- Final Summary Chart PDF*(https://techport.nasa.gov/file/139779)*

Images



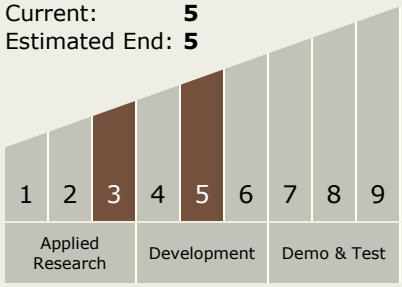
Briefing Chart Image
Innovative Fiber-Optic Gyroscopes (FOGs) for High Accuracy Space Applications, Phase II *(https://techport.nasa.gov/image/132303)*



Final Summary Chart Image
Innovative Fiber-Optic Gyroscopes (FOGs) for High Accuracy Space Applications, Phase II *(https://techport.nasa.gov/image/129255)*

Technology Maturity (TRL)

Start: **3**
Current: **5**
Estimated End: **5**



Target Destinations

The Moon, Mars, Outside the Solar System, The Sun, Earth, Others Inside the Solar System